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materials bureau technical services subdivision

TECHNICAL REPORT NO. 13

EVALUATION OF PROTECTIVE COATINGS FOR USE ON THE BARGE CANAL SYSTEM

September 1972

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(First Interim Report)

EVALUATION OF PROTECTIVE COATINGS FOR USE ON THE BARGE CANAL SYSTEM

September 1972

by

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ABSTRACT

To obtain a protective coating system that would be suitable for maintenance work on the State's Barge Canal system, several protective coatings were field tested on Lock 3 at Waterford, New York. The primary criteria for the consideration of any coating or coating system was that the minimum useful life be not less than ten years. In addition, the ease of application and the coatings ability to be applied in adverse weather conditions (during winter months when the canal system is closed) were of the upmost importance.

In all, five different coating systems were applied. Three of the systems utilized a zinc rich primer with varying topcoats. One system was of an epoxy type, and one was based upon a coal tar epoxy. Although durability characteristics of the coatings cannot be predicted at this time, the following recommendations, based upon observations at the time of application, were made:

1. With sandblasting equipment and material currently available to State maintenance forces, the use of a coatings system specifying a surface preparation greater than that of commercial sandblasting is not recommended.

2. Due to its minimum surface preparation requirements, ease of application and comparable cost to the State's standard coating system, it is recommended that the epoxy system be used on a limited basis, in lieu of the standard system, for maintenance work on the canal system.

CONTENTS

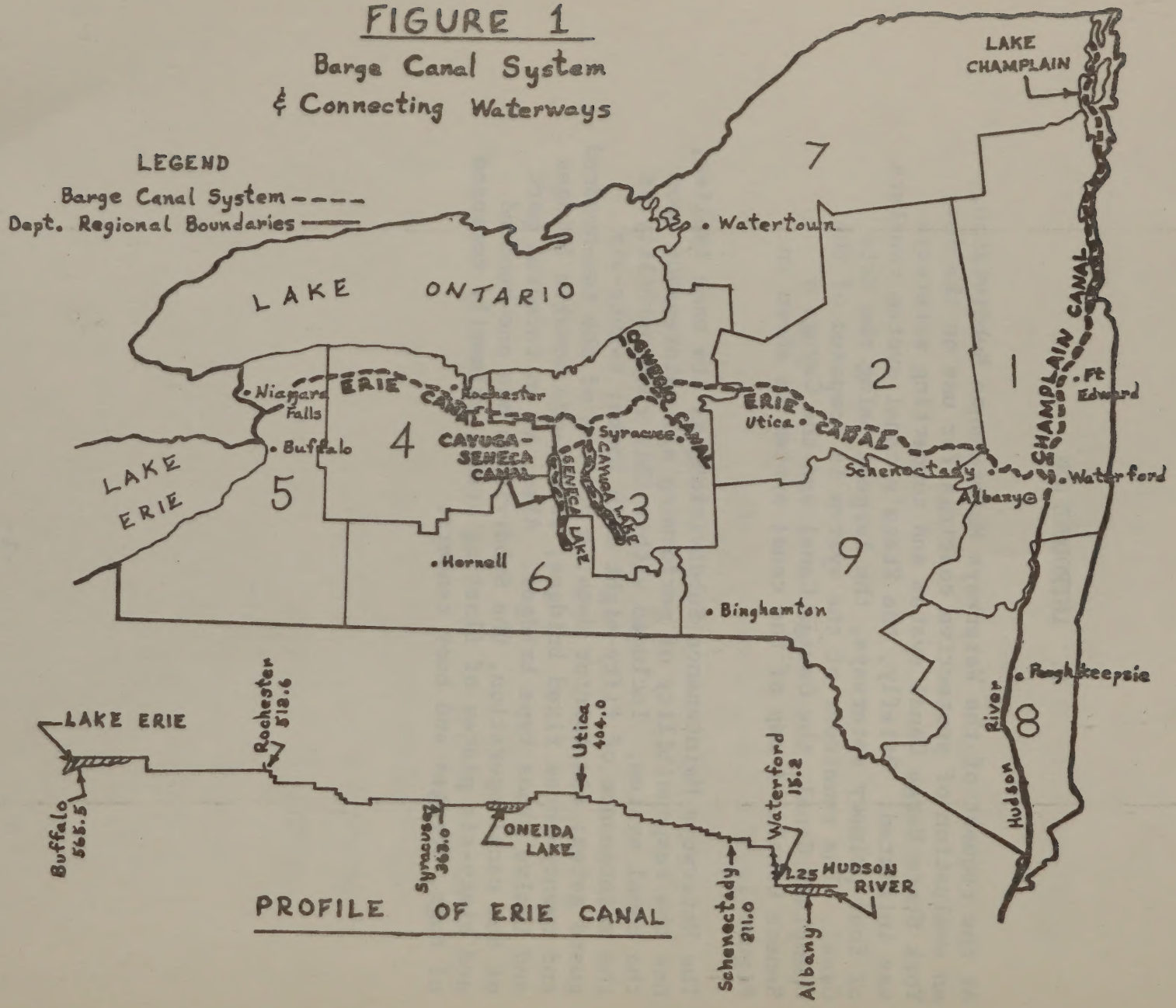
I. INTRODUCTION

At the request of the Waterways Maintenance Subdivision, an evaluation of protective coatings for use on the New York State Barge Canal system and connecting waterways was initiated. Briefly, the State's canal system consists of four primary waterways, the largest being the Erie Canal. The remainder of the system is composed of the Champlain Canal, the Oswego Canal and the Cayuga & Seneca Canal. A map of the canal system is shown in Figure 1.

The Waterways Maintenance Subdivision, as its name implies, has the responsibility of performing all maintenance upon the canal system. Included within this responsibility is the maintenance of fifty-eight main locks; twenty-six guard gates; six taintor dams; a portion of the two-hundred and twenty-three fixed bridges; twenty-one movable bridges and twelve truss type bridges. Also, as an integral part of the canal operation, the Subdivision has one-hundred and sixty-six pieces of floating craft, primarily composed of tugs, dredges and buoy tenders.

FIGURE 1

Barge Canal System & Connecting Waterways



PROFILE OF ERIE CANAL

II. BACKGROUND

In January, 1972, the Waterways Maintenance Subdivision requested that the Materials Bureau initiate a study of protective coatings which would be suitable for maintenance work on the canal system. The request was a result of the sporadic performance received from their standard maintenance coating, an asphaltic type consisting of tar base pitch blended with solvents; in some instances this coating had proven satisfactory, having a useful life of from 5-10 years while in others failure of the coating was noted in two years or less.

In this evaluation, the primary criteria for the consideration of any coating or coating system was that the minimum useful life be not less than ten (10) years. This was due to the approximate maintenance cycle for any particular lock on the canal system. Due to personnel and other limitations, the rehabilitation (repairs and application of protective coatings) of locks is performed once every 10 years. In addition to its minimum useful life, the coating would also have to be capable of withstanding continuous fresh water submersion, intermittent submersion (occurring when water levels are raised and lowered) and continuous atmospheric exposure in varying environments, ranging from a rural to heavy industrial and chemical, throughout the State. Also, it would be necessary for the coating to resist the abrading and scoring action of ice throughout the winter months.

The preceding deal primarily with the durability characteristics of the protective coating system. For use on the canal system, certain application requirements had to be met. Most maintenance operations are performed when the canal is closed to shipping; this occurs during the winter months,

generally starting on December 1 and extending into April. As a result, the protective coating systems are applied under less than ideal conditions; low temperatures, excessive dampness and occasional snowfalls are common occurrences. Painting under cover is not a common practice as the time involved in erecting covers, together with various repairs being performed in adjacent areas, renders it impractical.

In January and February, manufacturers were approached in attempts to obtain a coating system that would meet the afore described criteria. Through these contacts it became apparent that coatings meeting most or all of the requirements were of the "marine" type. Eventually, four companies were invited to participate in a coatings test program at Waterford, New York. Each company was requested to suggest a painting system(s) and also to supply material and technical assistance at the time of application. A total of eight (8) coatings systems were submitted for evaluation, however, due to unfavorable weather conditions and an early opening of the canal system, only five (5) systems were applied.

III. DESCRIPTION OF TEST AREA

The test area consisted of painting portions of the gates of Lock 3, on the Erie Canal, at Waterford, New York. This lock was selected as its geographical location allows for a natural de-watering when the canal system is closed and thus yearly inspections of the coating systems could be made. The gates are approximately 55± feet in height and 25± feet wide, however, the test area was confined to the lower portion, extending to a height of approximately 24½± feet. The coating systems were applied to the front and back of the two gates on the lower (downstream) end of Lock 3. The front of the gates, referred to as the "pocket side," are composed of a series of bays, in which are included stiffeners, braces and other structural components as shown in Figure 2. The back of the gates, referred to as the "skin side" consisted of welded steel plates. Figure 3 is an overall view of the pocket side of the gates on Lock 3 and Figure 4 is a schematic illustration of the gates.

Prior to cleaning, the gates showed heavy deposits of dirt and other foreign material, particularly on those portions that were continuously submerged. It should be noted that the water level in the canal, when opened for shipping is approximately 15 feet as measured from the bottom of the gate. The water level in the lock itself, fluctuates as craft are "locked" from one level to another. Sections of the gates above the water line were relatively clean with the previously used coating system intact. Prior to the application of the coatings, test areas were dry sandblasted by State personnel as described in the RESULTS AND DISCUSSION section of this report.

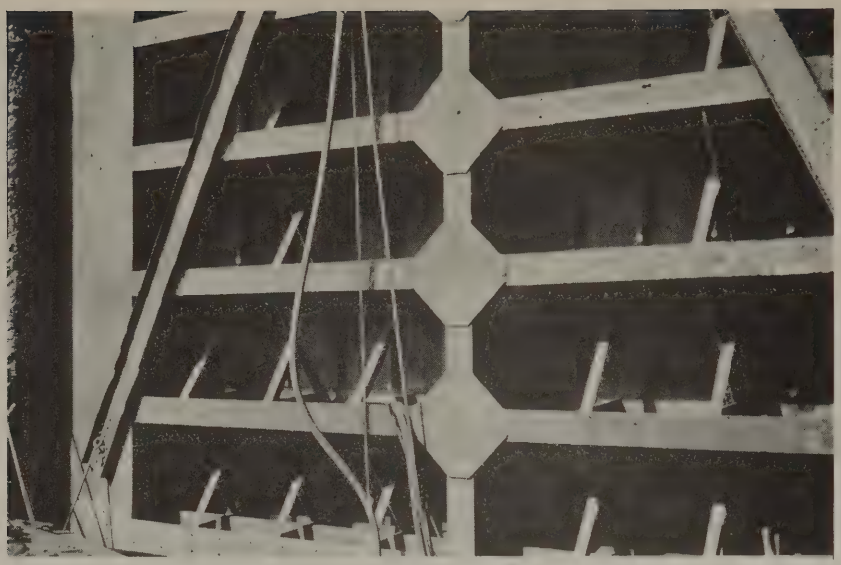
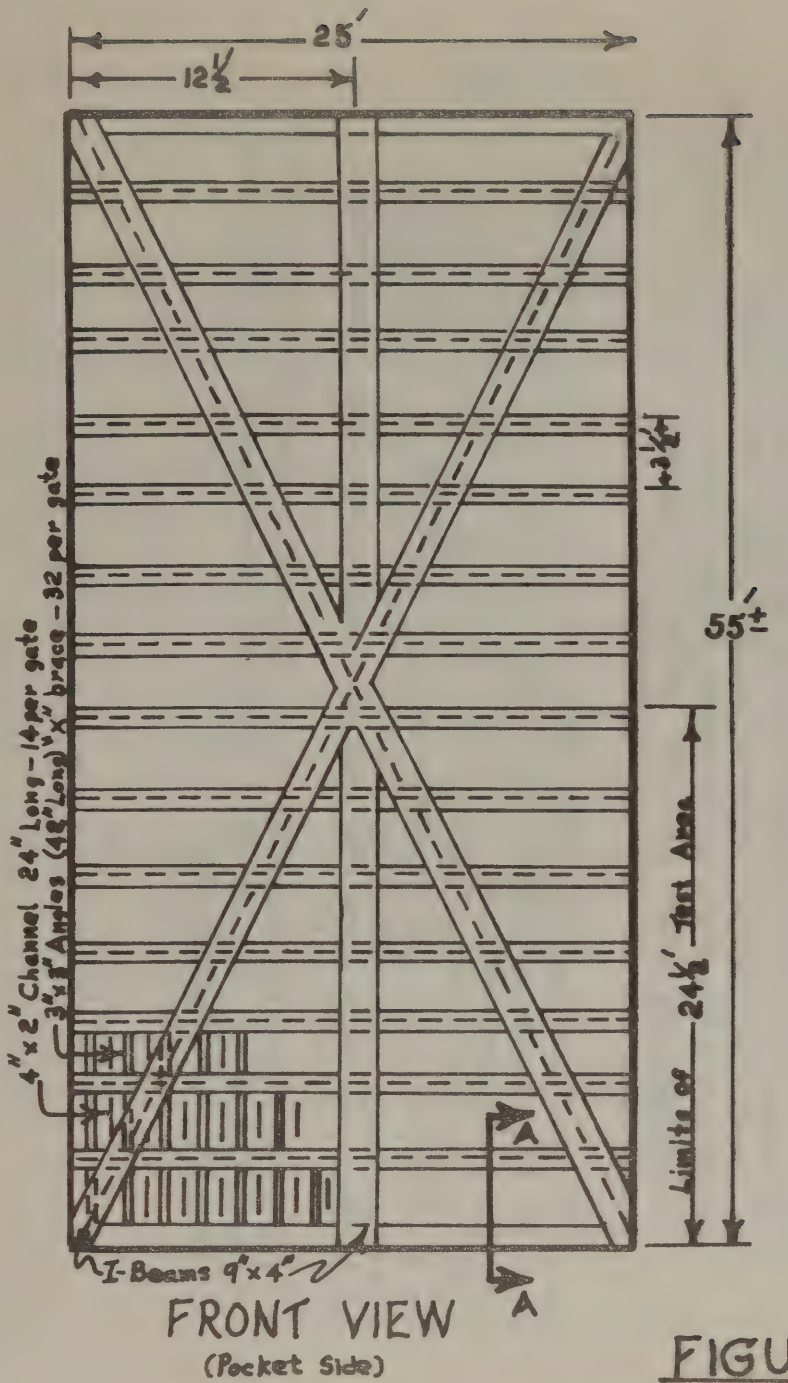


Figure 2 - "Pockets" in gates at Lock 3

Figure 3 - Overall view of gate at Lock 3



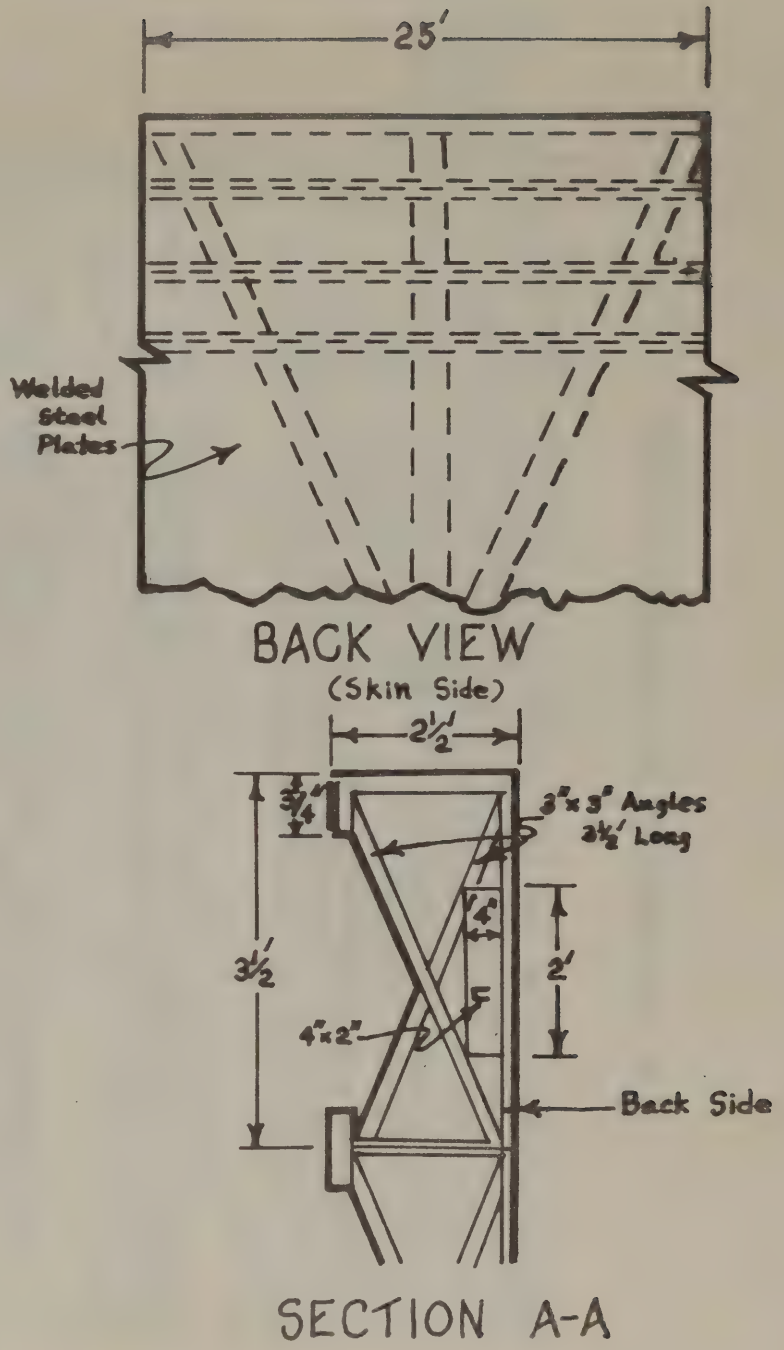


FIGURE 4

Schematic Illustration Of Gates

IV. DESCRIPTION OF COATINGS SYSTEMS

Original plans called for the application of eight coating systems at the test site. However, due to unfavorable weather conditions and an early opening of the canal system, only five of the systems, supplied by three of the manufacturers could be applied. Table 1 shows the manufacturers code and generic classification of the paint system(s); prime, intermediate and finish coats as applicable. Appendix A contains manufacturer's data on paints applied.

Although not included in the test, the three coatings which were unable to be applied were of the following types:

1. State's Standard Coating - A single application of a one component, asphaltic type paint, consisting of tar base pitch blended with solvents. (See Appendix A for manufacturer's data).

2. Two experimental systems consisting of a prime coat of organic anodic epoxy primer; an intermediate coat of organic anodic epoxy and finish coats of a high build epoxy type. Each of the paints in these systems (prime, intermediate and finish) consisted of two components.

Three of the coatings systems, A-1, A-2 and B-1 utilized some form of the commonly termed zinc rich primers, and manufacturers recommendations indicated extensive surface preparation in the form of near white or white metal blasting in accordance with the requirements of *SSPC-SP10 or SSPC-SP5 respectively. The advantage in utilizing the zinc rich type of primer was that once the initial application was completed,

* SSPC- Steel Structures Painting Council. Surface preparation specifications may be obtained from the Council at 4400 Fifth Avenue, Pittsburgh, Pa. 15213.

TABLE 1 - COATING SYSTEMS APPLIED

MANU-FACTURER (coded)	GENERIC CLASSIFICATION OF PAINT(s)		
	PRIME COAT	INTERMEDIATE COAT	FINISH COAT
* A-1	Zinc Rich, Inorganic Ethyl Silicate (2 component)	Basic Lead Silica Chromate Vinyl (1 component)	Vinyl Chloride (1 component)
A-2	Zinc Rich, Organic-based on chlorinated natural rubber vehicle (2 component)	Chlorinated Rubber (1 component)	Chlorinated Rubber (1 component)
A-3	Epoxy-Polyamide Cure (2 component)	-None-	Epoxy-Catalyzed (2 component)
B-1	Modified Zinc Rich, Inorganic (2 component)	-None-	High Polymer Epoxy (2 component)
C-1	-None-	-None-	Coal Tar Epoxy (2 component)

* Manufacturers have been designated as manufacturer A, B, or C. Also, the numeral after the manufacturers code designates a particular paint system, i.e., A-1 identifies the first paint system supplied by Manufacturer A.

subsequent maintenance work in the form of re-painting would only necessitate a brush-off blast and touching up or recoating of the intermediate and/or finish coats. This was based on the theory that the zinc rich primers, when properly applied, would last indefinitely; the organic types offering protection via the mechanism of self-sacrifice and the inorganic types working on the principal that they are inert and thus not susceptable to failure.

The epoxy system, A-3, offered the advantage of being compatible with surfaces receiving a minimum of surface preparation. Manufacturers recommendations were for the removal of loose rust, rust scale and mill scale by hand or power tool cleaning. For the purposes of the Waterways Maintenance Subdivision, the requirement of minimal surface preparation was considered as of the utmost importance.

The coal tar epoxy system offered the advantage of being applied in moderately heavy films, thus eliminating the need for a second or third coat. Also surface preparation requirements were not as critical with the manufacturer recommending a commercial to near-white blast.

V. RESULTS AND DISCUSSION

Application of the paint systems took place in the first part of April, 1972, and ended when the canal system was opened on April 17. Throughout the entire test, unfavorable weather conditions in the form of snow, rain, and below normal temperatures persisted. These conditions resulted in the application of the coatings in a less than favorable environment. Also, repairs on the lock in the form of unexpected welding, and the fitting of quoins, miters, bumpers, etc., in preparation of the opening of the canal system further hindered painting operations.

A. Surface Preparation

Initial cleaning of the gates preceded the application of the coatings by 2-3 weeks. This operation consisted of the removal of rust, heavy deposits of foreign material and most of the previously applied coating. Prior to the application of the coatings, the test sections received a second blasting in attempts to obtain the near white condition specified by most manufacturers. Weather permitting, the second cleaning generally preceded the application of the coating system by one day.

It soon became apparent that with both equipment and quality of blasting sand, utilized by the State's forces, it would not be feasible to obtain a near white surface preparation. Ceramic blasting nozzels (Standard #1) with a small ¼ inch orifice opening resulted in slow working progress. In addition, the cutting ability of the sandblast sand appeared to be poor and high breakdown rates were evident as shown in Figure 5 which plots the sieve analysis for samples of new and used blasting sand.

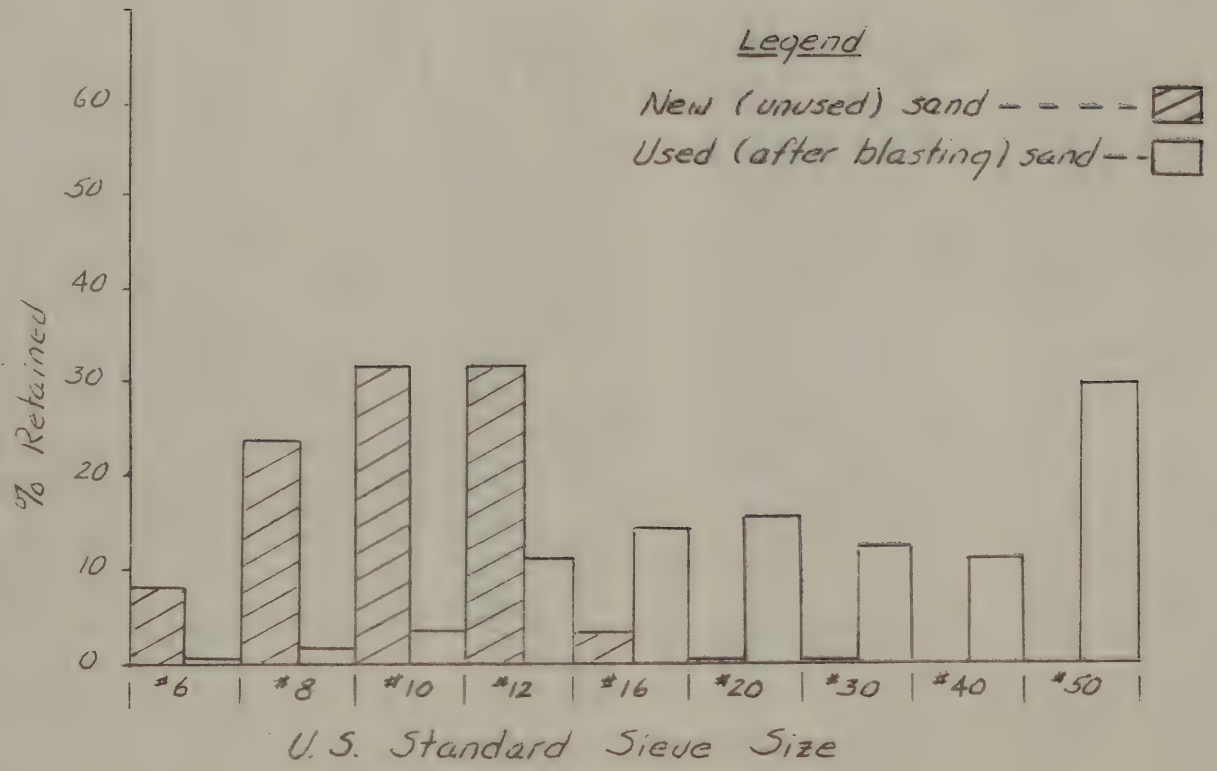


Figure 5 - Analysis of Sandblast Sand

Due to the difficulties in blasting, the majority of the test area received between a commercial (SSPC-SP6) and brush-off (SSPC-SP7) blast cleaning with comparable pictorial standards for the condition of the cleaned steel defined by ASTM D-2200 pictorial standards DSa2 and DSa1 respectively. Figure 6 is a photograph of a cleaned portion of gate in comparison with the pictorial standards.

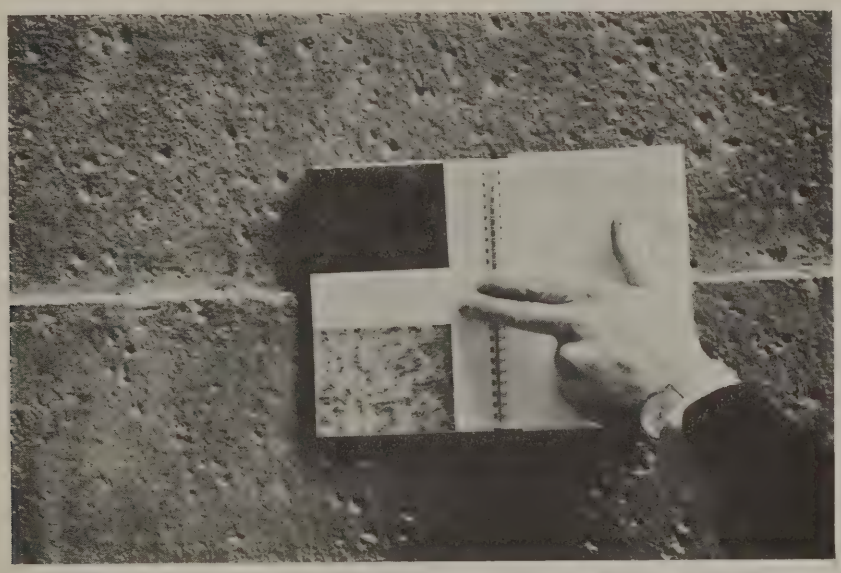


Figure 6 - Condition of cleaned steel

A small area on the skin side of the left gate was blasted by manufacturer A's representative to obtain a greater degree of surface preparation, for comparison of two of his systems (A-1 and A-2) with that portion of the test area which received the lesser degree of surface preparation. In this section the cleaned surface approximated a near white (SSPC-SP10) to commercial blast (SSPC-SP6) with comparable ASTM D-2200 pictorial standards of DSa2½ to DSa2 respectively.

B. Application Details

Each of the protective coatings were applied by State personnel by means of either conventional or air-less spray equipment. Prior to painting each paint was thoroughly mixed with mechanical mixers to insure uniformity of the product. Conventional spray equipment consisted of a Binks Model #62 spray gun with pressure pot, etc.. Air-less spraying was accomplished with a Speed-Flo spray gun, Model #801-102 and pump with 30:1 ratio.

At the time of application air temperatures, surface temperatures, relative humidity and wet film thicknesses were recorded. Also, general comments as to ease of application of the coating, dry times, and other pertinent information was noted. Dry film thicknesses were measured with a magnetic type dry film thickness gauge. Actual data, recorded at the time of application, together with each manufacturers recommended application details are summarized in Appendix B.

General comments and details on the application of each system tested are as follows:

1. System A-1

A three coat system utilizing an inorganic ethyl silicate zinc primer topcoated with vinyl intermediate and finish coats. The prime coat consisted of the two component type and was applied by conventional spray equipment. The vinyl intermediate and finish coats were of the one component type and were applied with airless spray equipment. Each of the three coats were applied without difficulty, despite the fact that snow was falling at the time of application of the prime coat. The application of the intermediate coat occurred four days later with the finish coat being applied four (4) hours after the intermediate. Appendix B gives the manufacturers recommended and the actual measured conditions and film thicknesses for the entire paint system.

2. System A-2

A three coat system consisting of a two component organic zinc rich primer, based upon a chlorinated natural rubber vehicle, with one component chlorinated rubber type intermediate and finish coats. Again the prime coat was applied by conventional spray equipment. The chlorinated rubber intermediate and finish coats were sprayed with airless equipment after thinning in a 10:1 ratio (paint:xylene). Thinning was performed on the manufacturers recommendation that this would eliminate any "cob-webbing" of the chlorinated rubber type paints. Actual recommendation was that 1 part of thinner be added to each 5 gallons of paint, and as applied (thinned 10:1) a very slight amount of "cob-webbing" was evidnet. No difficulty was encountered in applying any coat despite a snowfall during the application of the prime coat. Recoating with the intermediate and finish coats was accomplished four days and four hours respectively after application of the prime coat. Appendix B includes detailed information on the application of this system.

3. System A-3

A two coat system utilizing a two component epoxy wash coat with a two component epoxy finish coat. The wash coat was of a pretreatment type, designed to penetrate rust together with other foreign material. The pretreatment was applied by airless spray as the conventional unit was not functioning at the time. The spray was similar to that obtained from a fine garden hose spray and film thicknesses were so thin as to be immeasurable. A high degree of "wetting" ability was evident and application of the pretreatment was both rapid and easy. The finish coat was applied with the airless unit within 10-20 minutes after application of the wash coat. Again the coating was easily applied and no problems were encountered.

From the standpoint of ease and convenience, this system appears to be best for use on the Canal system; only minimum surface preparation is required and by using two spray units, one for application of the wash coat and one for the finish coat, the complete system could be applied simultaneously with no down time. Application details are included in Appendix B.

4. System B-1

A two coat system consisting of a two component inorganic modified zinc rich primer with a two component high polymer epoxy topcoat. Both the prime and finish coats were applied by airless spray. In all due fairness to the manufacturer it should be noted that this system was applied on the last day of the work week and prior to the flooding of the canal approximately 48 hours later. As a result, not all sections of the test area which were primed were topcoated. These primed areas will be evaluated at later dates, however, they shall not be considered as representative of the coating system. In general no difficulties were encountered in applying either the zinc rich primer or topcoat, however, the painters did notice that the zinc rich primer was more difficult to spray and apply at recommended film thicknesses than previously applied primers of this type. Application details are included in Appendix B.

5. System C-1

A two component coal tar epoxy applied in fairly heavy films in two coats. This system was supplied for purposes of evaluation by the manufacturer of the State's standard coating (Refer to Appendix A). One of the advantages of the coating was its ability to be applied over surfaces with a lesser degree of surface preparation; from a commercial to near-white blast. No difficulties were encountered in applying the coating with the airless equipment, however, time limitations dictated that only one coat sprayed at heavier than recommended thickness could be applied. Application details are included in Appendix B.

VI. COST ANALYSIS

Manufacturers participating in the test program were requested to submit a cost breakdown of materials applied on the basis of cents/square foot/recommended dry film thickness. To these material costs, monies for labor to apply the paint and to obtain the recommended degree of surface preparation were added to obtain the total cost for each of the coatings systems. A cost breakdown of the expenses for compressors, spray equipment, blasting equipment, solvents, etc., have not been included.

A labor cost for the application of one coat of paint was considered as five cents per square foot (5¢/sq.ft.), irrespective of recommended film thickness. Included within this figure is the time spent for paint preparation, positioning ladders and scaffolding and clean-up operations.

Surface preparation costs were based upon the following rates:

Near-White Blast - 32¢/sq.ft.
Commercial Blast - 13¢/sq.ft.
Hand Cleaning - 13¢/sq.ft.

When manufacturers recommendations allowed a "range" for surface preparation, such as between a commercial to near white, the average cost of these two degrees of surface preparation was used.

Table 2 shows the results of the cost analysis for both the State's Standard System and each of the experimental coatings.

TABLE 2 - COST ANALYSIS OF COATINGS SYSTEMS

System	Manuf. Recommended Dry Film Thickness (mils)	Mat'l Cost (¢/sq.ft.)	Labor Cost (¢/sq.ft.)	Manuf. Recommended Surf. Prep.	Surf. Prep. Cost (¢/sq.ft.)	Total Cost (¢/sq.ft.)
A-1 Prime Coat	3	6	5	Near-White	32	
Intermediate Coat	1	2	5	----------	----	
Finish Coat	6	8.4	5	----------	----	
TOTALS	10	16.4	15		32	63.4
A-2 Prime Coat	3	5	5	Near White	32	
Intermediate Coat	5	5.5	5	----------	----	
Finish Coat	5	5.5	5	----------	----	
TOTALS	13	16.0	15		32	63.0
A-3 Prime Coat	----	1.5	5	Hand Clean	13	
Intermediate Coat	----	----	----	----------	----	
Finish Coat	10	10	5	----------	----	
TOTALS	10+	11.5	10		13	34.5
B-1 Prime Coat	3	5.3	5	Near White	32	
Intermediate Coat	----	----	----	----------	----	
Finish Coat	8	6.5	5	----------	----	
TOTALS	11	11.8	10		32	53.8
C-1 Prime Coat	8	6.7	5	Commercial	22.5	
Intermediate Coat	----	----	----	Near White	-----	
Finish Coat	8	6.7	5	----------	-----	
TOTALS	16	13.4	10		22.5	45.9
New York Standard Prime Coat	15	4.7	5	Commercial	13	
Intermediate Coat	----	----	----	----------	----	
Finish Coat	15	4.7	5	----------	----	
TOTALS	30	9.4	10		13	32.4

VII. RECOMMENDATIONS

Although this initial report is primarily concerned with presenting information pertaining to materials and application of coatings systems at the test area in Waterford, and information on the durability of any coating system is not available, the following recommendations appear warranted:

1. With the sandblasting equipment and material currently available to State maintenance forces, the use of a coatings system specifying a surface preparation greater than that of commercial sandblasting is not recommended.

2. Due to its minimum surface preparation requirements, comparable cost ot the State's standard coating system and ease of application, it is recommended that the Waterways Maintenance Subdivision consider the limited use of the two coat epoxy system (A-3), in lieu of the standard system.

VIII. FUTURE WORK

Future work on this project will consist of a annual inspection of each coating system. These evaluations will be performed by personnel from the Materials Bureau and will include an overall visual inspection with particular emphasis on the durability of each coating. In addition, each coating system will be rated using pictorial or photographic reference standards in accordance with the following methods:

1. ASTM D-610, Evaluating Degree of Resistance to Rusting Obtained With Paint on Iron or Steel Surfaces.

2. ASTM D-714, Evaluating Degree of Blistering of Paints.

The results of each annual inspection and general comments on the performance of each coating system will be presented in future interim reports.

ACKNOWLEDGEMENTS

This study was conducted by personnel of the Materials Bureau, Harry, H. McLean, Director, under the administrative supervision and guidance of James J. Murphy, Assistant Director.

Although others from the Bureau were involved, the majority of the work was performed by John P. Ublacker, Principal Engineering Materials Technician and Michael J. Talmadge, Senior Engineering Materials Technician. Their assistance is sincerely appreciated.

Arrangements for the test area were made through Joseph R. Stellato, Director, Waterways Maintenance Subdivision. From this same unit the assistance of Wendell French, Canal Equipment Specialist and Edward Rowan, Associate Civil Engineer is appreciated.

Equipment and personnel to apply the coatings systems were supplied by Region 1, Waterways Maintenance section. The efforts of these men, under the direction of Al Ferris, General Canal Foreman, Section 2, is gratefully acknowledged.

Paints, technical assistance and other materials were supplied by the following companies: Devoe & Raynolds Co., Inc., New York, N.Y.; Koppers Company, Inc., New York, N.Y.; and the Prufcoat Division, Grow Chemical Coatings Corp., Cleveland, Ohio.

APPENDIX A

MANUFACTURERS PAINT DATA

NEW YORK STATE DEPARTMENT OF TRANSPORTATION STANDARD SYSTEM

General Characteristics:	A black, self-priming, heavy duty protective coating composed of a tar base pitch blended with selected solvents to a heavy paste-like consistency.
Preparation of surfaces:	Before applying to metal surfaces, dust, dirt, loose mill scale, welding scale, rust, oil, unbonded or incompatible paint, grease, residual acids, alkalies or other foreign matter must be removed as completely as possible from the surfaces to be coated. It is recommended that rust scale and paint be removed by sand or grit blasting, hand or power brushing and/or scraping.
Rate of application:	Apply at a rate of 55-70 square feet per gallon per coat (equivalent to a dry film thickness of 15-18 mils); at least two coats should be applied. The first coat must be thoroughly dry before the application of the succeeding coats.
Drying time:	Surface dry in approximately 24-48 hours at the specified application rate under normal atmospheric conditions.
Packaging:	55 gallon, 18 gage tight-head drums, 5 gallon steel pails, 1 gallon cans.

SYSTEM A-1

PRIME COAT

Generic Type:	Inorganic Zinc Silicate.
Description:	A two-package, self-curing inorganic primer based on a silicate vehicle.
Color:	Red.
Solids Content:	Average - 80% by weight; 43% by volume.
% of Zinc in Dry Film:	Average - 85%.
Weight per Gallon:	Average 22 lbs. (furnished in one gallon kits).
Initial Viscosity:	19 Sec. #4 Ford Cup Mixed.
Flash Point:	71°F. Tag Open Cup.
Pot Life:	12 hours @ 75°F.
Shelf Life:	6 months.
Surface Preparation:	Immersion Service - White Blast according to SSPC-SP5-63 is preferred. For other exposures - Near White Blast according to SSPC-SP10-63 is preferred. Before blasting, all mill grease, oil spots, etc., should be removed by suitable methods such as chemical cleaners, solvent wash, or organic detergent wash. Coating must be applied to a surface prepared in accordance with the above specifications, and which is free from all oil, grease, dust, dirt and other surface contamination.

Application Equipment:	Devilbliss MBC or JGA Gun equipped with H.D. fluid spring, E fluid tip, and needle and 64 Air Cap or equivalent in other guns. This is for external mix application. For internal mix application use the following or equal: Eclipse G.A.T. Gun with E-44 fluid tip and air cap to produce width of fan desired, such as #17 for small, #27 for medium, #37 for large fan. Internal mix guns should also be equipped with H.D. fluid springs and teflon coated fluid needle with tungsten-carbide tip. Equivalent equipment of other manufacturers is acceptable. To obtain smooth uniform finish with best edge protection, proper spray application techniques must be used. Brush application should be used for touch-up only, using a medium bristle brush and stirring material frequently. Apply with a full brush and avoid re-brushing as much as possible. Addition of thinner may be required to eliminate brush strokes.
Application Conditions:	Temperature - 0°F. to 200°F. Relative Humidity up to 95%. Can be applied over slightly damp surfaces.
Number of Coats & Thickness:	Normally one coat required with film thickness of 2½-3 mils. Can be applied at thicknesses of 3-6 mils.
Drying and Curing Time:	To touch - 20 minutes. To handle - 1 hour. To topcoat - 6 to 8 hours. Prime Coat requires moisture to cure properly; the recoat time may be accelerated or delayed by humidity conditions. A water spray may be used to accelerate hardening. A fine mist spray is the most effective method of wetting the surface. At low humidities, several applications of water may be required.

Coverage:	Theoretical - 690 sq. ft. per mil/gal. Actual - Approx. 800 sq. ft./mil/gal.
Resistance:	Salt Spray - excellent. Abrasion - good. Solvents - excellent. Flexibility - fair. Moisture - excellent. Impact - very good. Weather - excellent.

INTERMEDIATE COAT

Generic Type:	Vinyl resin.
Description:	An inhibited, pigmented, vinyl resin.
Color:	Tile Red.
Solids Content:	Average - 37.0% by weight; 21.0% by volume.
Weight per Gallon:	Average 8.6 lbs.
Initial Viscosity:	1150 $\pm$ cps. Brookfield 20 rpm, at 78^{o}F.
Flash Point:	97^{o}F., Tag Open Cup.
Shelf Life:	One Year.
Surface Preparation:	Loose rust, rust scale, and loose mill scale must be removed. In severely corrosive environments, all rust and mill scale must be removed. Methods in order of effectiveness are: sandblasting, power tool cleaning, hand tool cleaning. Oil and grease must be removed by solvent or detergent washing. Acid or alkali contaminated surfaces must be neutralized. All other contaminates must be clean and dust-free.
Application:	Brush, roller, or spray.

Application Conditions:	Do not apply below 40°F. ambient temperature.
Number of coats and thickness:	One coat normally recommended. Two coats may be recommended for brush application on exceptionally rough surfaces. Thickness per coat: 2 to 3 dry mils by hot spray; 1½ to 2 dry mils by conventional spray; 1 dry mil by brush or roller.
Theoretical Coverage:	335 Sq. ft./mil/gallon.
Drying Time:	To topcoat - 1 to 2 hours; 30-60 minutes hot spray.
Resistance:	Weather - Good. Chemicals - Good. Solvents - Good. Impact - Excellent. Flexibility - Excellent.

FINISH COAT

Generic Type:	Vinyl chloride - acetate copolymer solution.
Description:	High-molecular-weight vinyl chloride-acetate copolymer solution resins, inert pigments, plasticizers, and modifiers in mild ketone solvents.
Colors:	As specified.
Solids Content:	Average - 50% by weight; Average - 33% by volume.
Weight/Gallon:	Average - 9.7 lbs.
Initial Viscosity:	Brookfield 20 rpm, 1000 to 1400 at 78°F.
Flash Point:	72°F. Tag Open Cup. 38°F. Pensky Marten Closed Cup.

Pot Life:	Indefinite.
Shelf Life:	Over One Year.
Recommended Use:	Corrosion Control in new or old construction.
Surface Preparation:	Over a primed, clean, dry surface.
Application:	Airless spray pump; 24 to 1 ratio or more. Devilbiss JGA-5026 or DeVilbiss JGB gun or equivalent. Nozzles from .015 to .018 with fan angles of from 40° to 65°. Atomizing pressure, 1450 psig.
Application Conditions:	Temperature - 40°F. (minimum). Relative humidity - not critical.
Number of Coats & Thickness:	Normally a single pass or one cross coat to provide 5 - 10 mils of dense, pore-free film
Drying & Curing:	To touch - 30 minutes. To recoat - 7 hours.
Theoretical Coverage:	525 Sq. Ft./mil/gallon.
Resistance:	Alkalies - excellent. Chemical - excellent. Solvents - fair. Weather - excellent. Acids - very good. Abrasion - excellent. Impact - excellent.

SYSTEM A-2

PRIME COAT

Generic Type:	Organic zinc rich primer based on a chlorinated natural rubber vehicle.
Color:	Gray (when mixed).
Solids Content:	Average - 80.2% by weight.
% Zinc in dry applied film:	85.0%.
Weight per Gallon:	20.6 lbs.
Initial Viscosity:	Base component - 1300 cps $\pm$ 100 #4 @ 20.
Flash Point:	Over 81°F. Tag Open Cup.
Pot Life:	Over 24 hours.
Shelf Life:	One year.
Surface Preparation;	Near White Blast according to SSPC-SP10-63T is preferred.

Before blasting, all mill grease, oil spots, etc., should be removed by suitable methods such as chemical cleaners, solvent wash, or organic detergent wash.

Coating must be applied to a surface prepared in accordance with the above specifications, and which is free from all oil, grease, dust, dirt and other surface contamination.

Application Equipment:

Devilbiss MBC or JGA Gun equipped with H.D. fluid spring, E fluid tip, and needle and 64 Air Cap or equivalent in other guns. This is for external mix application. For internal mix application use the following or equal: Eclipse G.A.T. Gun with E-44 fluid tip and air cap to produce width of fan desired, such as #17 for small, #27 for medium, #37 for large fan. Internal mix guns should also be equipped with H.D. fluid springs and teflon coated fluid needle with tungsten-carbide tip.

Equivalent equipment of other manufacturers is acceptable.

Spray - To obtain smooth uniform finish with best edge protection, proper spray application techniques must be used. Conventional external mix spray application requires the following:

1. A pressure pot equipped with moisture and oil separator, dual pressure regulator and gauges, and an air motor driven agitator with ½" I.D. fluid hose, 25 ft. length preferred and not to exceed 50 feet. The air line from the pot to the gun should be 5/16" or 3/8" I.D. Minimum hose size from compressor to pot ½" I.D.

2. Fluid line pressure and atomization pressure must be adjusted to produce a uniform, finely atomized wet film while holding the gun at right angles to the surface at approximately 8", using a 50% overlap on each pass. This distance will vary with temperature and wind.

Note: Normal pot pressure is 15-20 psi and normal atomization pressure is 45-60 psi, but these will vary depending on climatic conditions.

3. Pressure pots, hoses, and guns must be at the same level or above the surface to be coated. Since zincs cannot easily be pushed upward more than 5 feet, this precaution is taken to prevent zinc build-up in the line and consequent gun spitting.

4. When spraying is stopped for longer than 15 minutes, material should be blown back from the gun and fluid line into the pot to prevent zinc from settling out in the hose.

5. On sharp edges, irregular surfaces, etc., a light wet coat should be applied first to these areas to assure full coverage and then covered with the specified film thickness.

Note: Internal mix guns will be set up on the same manner but fluid and atomization pressures should be adjusted for best equipment performance.

Brush - Brush application of zinc should be used for touch-up only, using a medium bristle brush and stirring material frequently. Apply with a full brush and avoid rebrushing as much as possible.

Application Conditions:	Temperature - 35° - 100°F. Relative humidity - 0 - 80%.
Number of coats & thickness:	One coat of 3 dry mils is recommended.
Curing and Drying Time:	To touch - 2 hours. To handle - 6-8 hours. To topcoat - 16 hours.

The drying times listed above are based on optimum conditions (70°F., R.H. 50-70%) for sprayed films.

For immersion service, painted steel should dry 1 to 2 weeks.

Theoretical Coverage: 862 sq.ft./mil/gallon.

Resistance:

Solvents	- fair.	Abrasion	- very good.
Moisture	- excellent.	Flexibility	- very good.
Weather	- excellent.	Impact	- very good.

INTERMEDIATE AND FINISH COATS

Generic Type: Chlorinated Rubber.

Description: A non-oil-modified chlorinated rubber coating designed for spray application.

Color: White and Light Gray.

Solids Content: Average - 50.6 by weight; 30.95 by volume.

Weight per Gallon: 9.98 lbs.

Initial Viscosity: 65-70 KU.

Flash Point: 40°F.

Shelf Life: Indefinite.

Surface Preparation: All surfaces to be coated should be thoroughly cleaned of all dust, dirt, oil, grease and other contaminants using a good organic detergent, rinsed thoroughly and allowed to dry before coating. Solvent washing is not recommended.

On steel surfaces - For non-immersion service, a commercial sandblast (SSPC-SP6-63) is adequate. For immersion service, a near white sandblast (SSPC-10-63) is recommended.

Thinning:	For spray add 2-3 pints of xylene as necessary for proper flow-out and to eliminate overspray.
Application:	Spray application is recommended. For conventional spray use Devilbiss MBC or JBA gun with "FF" or "E" fluid tip and #704 or #765 air caps. For airless application use .015 - .019 orifice tip and 40°-60° angle fan. If brushing is required, apply a full, wet coat to the surface with a minimum of "brushing out".
Number of coats and thickness:	2 to four dry mils per coat. Ten wet mils will yield a dry film thickness of 2 - 2½ mils.
Theoretical Coverage:	500 sq. ft. at 1 dry mil. Actual coverage will average 200 sq. feet per gallon at 2 dry mils.
Drying Time:	Dry to touch - 30 minutes. Dry to recoat - 1/2 to 2 hours. Dry to handle - 1 to 2 hours.

Chemical Resistance:

Alkalies	- good.	Acids	- good.
Salt Spray	- excellent.	Abrasion	- good.
Solvents	- not recommended.	Fumes	- excellent.
Moisture	- excellent.	Mildew	- excellent.
Oils	- (Mineral) fair.	Corrosion	- excellent.
Oils	- (Vegetable) not recommended.		
Washing	- excellent.		

SYSTEM A-3

PRIME COAT

Generic Type:	Polyamide cured epoxy.
Description:	A pretreatment for imperfectly cleaned surfaces; designed to wet out the surface and penetrate water vapor film, pin hole pores, and adherent rust films.
Color:	Clear:
Solids Content:	Average: 9.8% by weight; 7.7% by volume.
Weight per Gallon:	Average - 7.6 lbs.
Initial Viscosity	7 centipoises @ 78°F. (Mixed).
Flash Point:	85°F., Tag Open Cup.
Pot Life:	Exceeds 90 days @ 65°F., storage above 65°F. will shorten life.
Shelf Life:	Unlimited (unmixed).
Blending Instructions:	Furnished as a two-part material, the base solution and the curing agent. Add the curing agent to the base solution and mix well.
Surface:	Remove loose rust, rust scale, and loose mill scale by hand or power tool cleaning. Oil and grease must be removed by solvent or detergent cleaning. Acid or alkali contaminated surfaces must be neutralized. Other contaminants must be removed.

Application:	Apply in a wet, flooding type coat. Virtually any method of application can be used: brush, roller, spray, dip, mop, or squeegee.
Application Conditions:	During application and curing, ambient temperature should be 50°F. or above.
Drying Time:	10 minutes. Allow to dry tack free, them immediately apply the subsequent coat to assure maximum bonding to the metal.
Coverage:	500 sq.ft./gallon over typical surface.

FINISH COAT

Generic Type:	Catalyzed epoxy.
Description:	A heavy-bodied, fibrated epoxy mastic containing inhibitive pigments.
Color:	Brick Red, Olive, Copper, and Ochre.
Solids Content:	Minimum: 71% by weight; 46% by volume.
Weight per Gallon:	13.6 $\pm$ 0.2 lbs.
Initial Viscosity:	Brookfield 20 rpm. No. 3 spindle 3500 cps @ 78°F.
Flash Point:	Above 80°F.
Pot Life:	Useful application life after adding catalyst is 16 hours @ 78°F. Higher temperatures will shorten pot life.
Blending Instructions:	Catalyst is added prior to use at rate of 4 fluid ounces (118 ml.) per gallon.

Surface Preparation:	Loose rust, rust scale, and loose mill scale must be removed. For some services all rust and all mill scale must be removed. The method recommended in each case depends on the surface conditions, intended service, and other factors. Methods, in order of effectiveness, are: sand-blasting, power-tool cleaning and hand-tool cleaning. Oil and grease must be removed by cleaning in solvents or detergents. Acid - or alkali-contaminated surfaces must be neutralized. Other contaminants must be removed. Surfaces must be dust-free, clean, and dry.
Application:	Spray. Brushing is difficult and should be limited to small areas. Spraying may be by conventional, airless, or hot-spray methods.
Conventional Spray:	Use Binks #19 gun with #69 fluid tip, T1235-156 needle, and 69 PB air cap, or equivalent. Atomizing pressure should be set at a point where it barely breaks up the material. Excessive atomizing pressure can result in pin-holding and film irregularity. The pressure pot should have a separate regulator for atomizing air in order to control pressure.
Airless Spray:	Use pump with a ratio of 20 to 1 up to 30 to 1, with a 0.024" to 0.036" tip, and a spray angle of 40° to 65°. Remove all screens and filters.
Hot Spray:	May be hot-sprayed at 110°F. by using a non-circulating heater. Higher temperatures are not recommended, as they greatly shorten pot life.
Number of Coats and Thickness:	Only one coat required. One single-pass spray coat yields 5 to 10 dry mils, which is the usual thickness range. If additional thickness is desired, cross passes can be used to build up the coating in excess of 20 dry mils.

	May be topcoated with suitable topcoats for decorative color or for additional chemical resistance.
Drying Time:	Tack free: 2 to 4 hours. To handle: 6 to 8 hours. To topcoat: overnight at 60°F. Complete cure: 5 days at 78°F.
Theoretical Coverage:	Theoretical coverage is 735 sq. ft. per gallon per dry mil coating thickness. Actual coverage is less than this and will vary, owing to difference in surface roughness, total coating thickness, size and shape of the object being coated, skill of the applicator, method of application, and conditions under which the application is made. For purposes of estimating a loss factor of 25% can be used. This yields a coverage of 550 sq. ft. per gallon per dry mil thickness. Individual cases may call for a revision, up or down, of this estimate.
Weathering:	Excellent. No checking or cracking; some loss of gloss on long exposure.
Chemical and Solvent Resistance:	Excellent resistance to salt spray, sea water, organic solvents, fuels, strong alkalies, and alkaline and acid salts. Shows no visible deterioration after 3600 hours in ASTM salt-spray test on KTA panels. Withstands over 500 Butterworth cycles without failure.
Physical Properties:	Unusually high abrasion and impact resistance. Flexibility: 10-mil film passes ½" mandrel bend test.
Limitations:	During application, ambient temperature should be 50°F. or above; relative humidity should be below 85%. A minimum temperature of 50°F. is required for curing within a practical time interval (see "Drying Time" above). Do not apply to wet, damp, dusty, or dirty surfaces, or over loose rust, rust scale, loose mill scale, or chemical contaminants.

SYSTEM B-1

PRIME COAT

Description:	A self curing, modified inorganic zinc coating.
Colors:	Brown - Green - Gray.
Packaging:	One gallon piggy-back cans. Zinc is ready-mixed in paste form, merely thin down by mixing in reducer which is in small can on top.
Surface Preparation:	All surfaces to be coated shall receive a Near White Blast Cleaning. This shall be at least equivalent to SSPC-SP 10-63T Near White Blast Cleaning.
Application:	All types of application equipment from roller to airless spray. For spray application, be sure that equipment is set up so that both fluid pressure and atomization air pressure can be independently regulated. A valuable point to remember is that the fluid pressure requirement is lower than for other products; excessively high fluid pressure will cause pock marks and/or pin holes in the film.
Film Thickness:	A minimum dry film thickness of 3.0 mils should be applied.
Spreading Rate:	The practical spreading rate allowing for normal losses is approximately 200 square feet per gallon which will yield a minimum dry film thickness of 3.0 mils.
Reduction & Mixing:	Regardless of the method of application, material should be mixed in the exact proportion in which the components are supplied (1/5 gallon of Reducer to 4/5 gallons of Paste). Care should be taken to be sure material is thoroughly mixed.

equipment should be cleaned within one hour after application has stopped.

FINISH COAT

General Characteristics:	A two component high polymer epoxy.		
Component Ratios: By Volume.	Base 4	to	Convertor 1
Induction Time:	15 minutes.		
Pot Life:	5 hours at 77°F.		
Dry to Re-coat Time:	4 hours minimum at 68°F.		
Flash Point:	Over 80°F. T.O.C.		
Dry Film Thickness: (mils)	8.0		

Spreading Rate: (Theor. sq.ft./gal.): - 131

Wet Film Thickness (mils) - 12.4

Spreading Rate @ 1.0 Mil Dry Film - 1,045 sq.ft./gal.

Net Weight Per Gallon (lbs.) - 10.12.

Component Ratios by Weight (parts base to convertor) - 5.26:1.

Packaging: Two components supplied as a kit; available in five gallon kits.

SYSTEM C-1

General Characteristics:	A two component coal-tar epoxy chemically cured protective coating meeting all requirements of Corps of Engineers Specification C-200 and Government Specification MIL-P-23236.
Detailed Requirements:	Apply two coats at the rate of 100 to 120 sq. ft. per gallon per coat to provide a dry coating of 8 to 10 mils thickness per coat. The dry film thickness of two coats applied in this manner should not be less than 16 mils at its thinnest spots.
Surface Preparation:	Steel surfaces which are to receive this coating should be prepared by blast cleaning to a commercial grade. Where the surfaces are to be subjected to very severe chemical exposures or immersion service a minimum blasting to the near-white grade should be specified.
Application of Material:	Should not be applied at temperatures less than 50°F. as the coating will not properly cure. It should not be applied in wet weather. Regardless of the type of surface to be coated, allow not more than 24 hours maximum to elapse between coats. A stiff brush, rug-type roller, air-type spray or airless-type equipment may be employed for application. Avoid the use of nylon or plastic equipment.

Air Type Spray Data:	Pump	- Graco Mogul (8:1 ratio)
	Pressure: Material	- 30 to 55 psi
	Atomization	- 50 to 90 psi
	Fluid Tip	- 1/8 in. to 1/4 in.
	Atomizing Tip	- 3/16 in. Wing External
	Hose	- 1/2 in. to 50 ft., over 50 ft. 3/4 in.
	Max. Working Pressure	- 750 lbs.
	Min. Burst Pressure	- 3,000 lbs.

The equipment data given may be improved by using a heater with a material hose 1/2 in. in diameter, about 50 ft. long between the pump and the heater to remove pulsation. The temperature of the product leaving the gun should range between 85 and 120°F. Heater thermostat should be set to a maximum of 120°F. A heater is recommended if application is made at temperatures between 50 and 70°F.

Airless Type Spray Data:	Pump	- Graco (30:1 ratio)
	Line Pressure	- 70 to 90 psi.
	Tip	- 23 - 29 mil.
	Filter	- None.
	Hose	- 3/8" High Pressure.

Care of Equipment: If application is stopped for more than 15 minutes all equipment including brushes must be immediately cleaned to avoid solidification of the coating. After spray application, be certain the cleaner is recirculated through the equipment before shut-down. All nozzles and spray guns should be disassembled and washed thoroughly with the cleaner.

Packaging: Available in 1 and 5-gallon units. Components A and B are in separate cans.

APPENDIX B

COATINGS APPLICATION DETAILS

APPLICATION DETAILS

Paint System	Color	Air Temp. * M.R.	Air Temp. ** A.	Surface Temp. M.R.	Surface Temp. A.	Relative Humidity M.R.	Relative Humidity A.	Weather Conditions (Actual)	Surface Preparation M.R.	Surface Preparation A.	Spray Equipment	Thicknesses Wet Film M.R.	Thicknesses Wet Film A.	Thicknesses Dry Film M.R.	Thicknesses Dry Film A.	Recoat Time M.R.	Recoat Time A.
A-1 Prime Coat	Red-brown	0°F+	30 to 35F	+n.s.	30 to 40F	95%	60 to 80%	Cold, Snow	Near-White	Brush-off to Com.	Conventional	6-7 mils	6 mils	3 mils	2½-3 mils	6-8 hrs.	96 hrs.
Intermediate Coat	Red	40°F+	40F	n.s.	30F	n.s.	50%	Cloudy Clearing	----	----	Airless	7-10	8-10	1	1-1½	1-2 hrs.	4 hrs.
Finish Coat	Gray	40+	56F	n.s.	42F	Not. criti-cal	52%	Sunny	----	----	Airless	18	12	6	3½-4½	----	----
A-2 Prime Coat	Gray-blue	35+	30-35F	n.s.	30-40F	80%	60-80%	Cold, Snow	Near White	Brush off to Com	Conventional	4-5	5-8	3	2½-3½	16 hrs.	96 hrs.
Intermediate Coat	Light gray	n.s.	42F	n.s.	33F	n.s.	50%	Cloudy Clearing	----	----	Airless	9-10	12	3	2½-3½	½-2 hrs.	2½ hrs.
Finish Coat	Light gray	n.s.	40-45F	n.s.	35F	n.s.	52%	Sunny	----	----	Airless	9-10	12	3	4	----	----
A-3 Prime Coat	Clear	50+	52	n.s.	42	n.s.	40-50%	Sunny	Hand & Power Tool Cleaning	Brush-off to Com.	Airless	n.s.	++ n.a	n.s.	n.a.	10 Min.	20 Min.
Finish Coat	Red	50+	52	n.s.	42	85%	50	Sunny	-----	-----	Airless	20	8-10	10	6-7	----	----
B-1 Prime Coat	Green	45+	62	n.s.	58	Not criti-cal	35-45%	Sunny	Near-White	Brush-off to Com.	Airless	7-8	6-8	3	2½-3	n.s.	2½-3 hrs.
B-1 Finish Coat	Black	45+	65	n.s.	60	Not criti-cal	40	Sunny	----	----	Airless	n.a.	12-14	8	n.a.	---	---
C-1 (one coat only)	Black	50+	48	n.s.	35	85%	45-50%	Sunny	Com. to Near-White	Brush-off to Com.	Airless	n.a.	12-16	8-10	10+	----	----

Legend: * Manufacturers Recommendation (M.R.). ** A = Actual recorded data.
+ n.s. = not specified. ++ n.a. = not available.